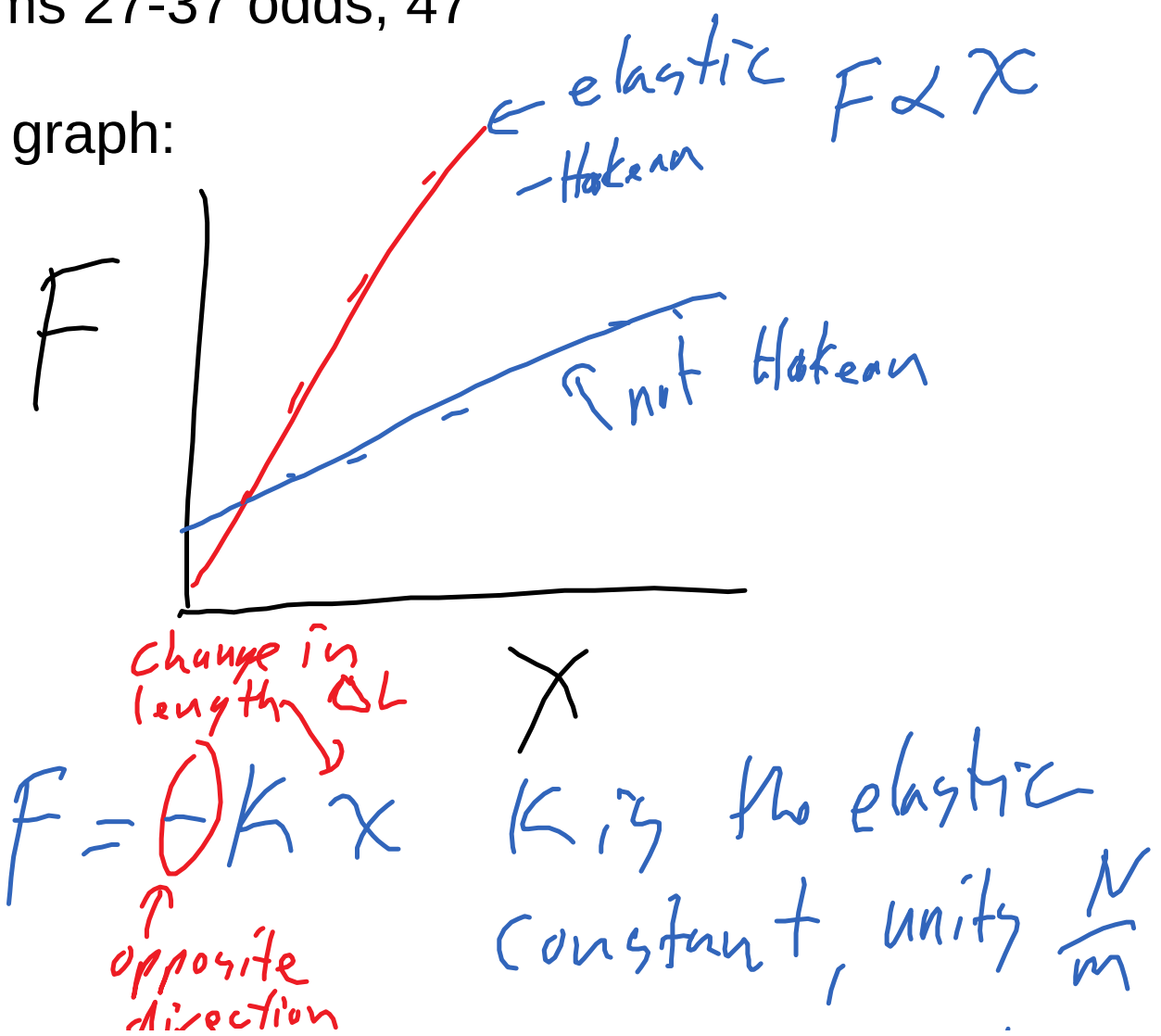
Gravity, Hooke and Work

Back to Newton/Cavendish:

1. What is the gravitational attraction between a 60.0kg student and a 50.0 kg student 1.5 m apart? Why don't they slide together. Fg =
2. g on Earth is 9.81 N/kg, if the radius of Earth is 6.38×10^6 m, what is it's mass?

Hecht p171-
problems 27-37 odds, 47

Hooke graph:



– elastic limit – object doesn't return to original shape

eg. 1. You hand a 500 g mass from a spring, length 14.0 cm and it stretches to 19.0cm.

a) what is the elastic constant of the spring?
b) if you pull the mass down 3.0 more cm and let go, what is the acceleration of the mass?
c) What is the acceleration when the mass returns to the 19.0 cm length?
d) How about when the spring is 16.0 cm?
e) bonus: what is the speed of the mass at equilibrium? - need work/energy to solve.

2. What is work? Who is doing more work, a student holding a pile of books, a student lifting a piece of paper or a student walking holding a book?

Back to Newton/Cavendish:

1. What is the gravitational attraction between a 60.0kg student and a 50.0 kg student 1.5 m apart? Why don't they slide together.
   $F_g = GMm/r^2 =$
   $6.67 \times 10^{-11} Nm^2/kg^2 \ (60kg \times 50kg)/(1.5m)^2$
   $6.67 \times 60 \times 50/(1.5 \times 1.5) = 8,893.3333$

$F_g = 8.9 \times 10^{-8} N$ alas the attraction is too small

2. g on Earth is 9.81 N/kg, if the radius of Earth is 6.38×10^6 m, what is it's mass?

$F_g = GMm/r^2 = mg$

$M = gr^2/G = 9.81 N/kg$

$(6.38 \times 10^6 m)^2 / 6.67 \times 10^{-11} Nm^2/kg^2$

$= 5.98 \times 10^{24} kg$

eg. 1. You hand a 500 g mass from a spring, length 14.0 cm and it stretches to 19.0cm.

a) what is the elastic constant of the spring?

$F = -kx \quad k = -F/x = -(-mg)/x = 0.50kg \times 9.8/5cm =$ 0.98N/cm or 98N/m

b) if you pull the mass down 3.0 more cm and let go, what is the acceleration of the mass?

$f = ma = 3.0cm \times 0.98N/cm = 0.50kg\ a$

$a = 5.8 m/s^2$

or

$F_{net} = F_t - F_g = ma$

$x = 5.0\ cm + 3.0cm = 8.0cm$

$0.98N/cm \times 8.0\ cm - 0.50\ kg\ 9.8N/kg = 0.5kg\ a$

$a = 5.8 m/s^2$

c) What is the acceleration when the mass returns to the 19.0 cm length?

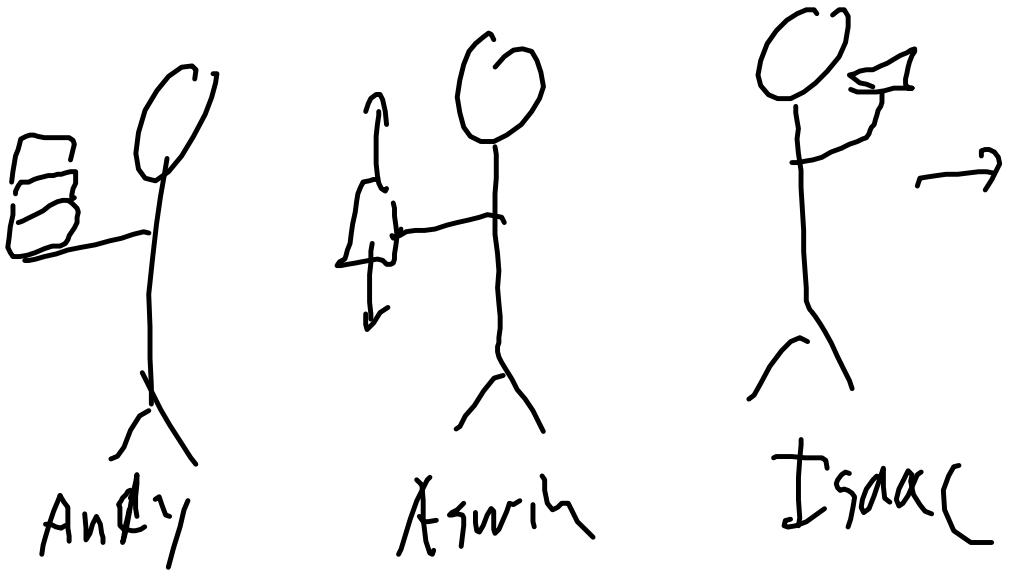
a=0 the elastic force = Fg so Fnet = 0

d) How about when the spring is 16.0 cm?

$a=-5.8m/s^2$ (down)

a) bonus: what is the speed of the mass at equilibrium? - need work/energy to solve.

1. What is work? Who is doing more work, a student holding a pile of books, a student lifting a piece of paper or a student walking holding a book?



The answer depends on how you word the question and the distinction between work and physical work.
physical work W is the vector dot product of force and displacement.
the component of force in the direction of motion.
W=Fs if F and s are in the same direction.
if F is constant - W= area under the F-s graph
So for Andy s=0 so W=0

Isaac F is perpendicular to s, so W=0 on the book
Aswin was doing work at any point W=Fs but if it returned to the same point, W=0.

Another way of looking at work is the work-energy theorem.
$W=\Delta Energy$

Work causes a change in energy
Energy is the ability to do work

Andy was using biological energy to hold the books, so you could say he was doing work but watch out, most of the time we are looking for physical work.

units: Joules, $J=Nm = kgm^2/s^2$

Work is a scalar - no direction, even though

force and s are vectors.
if F and s are opposite, work is negative - you are losing energy.

Power is rate of doing work, P=W/t
units: Watt, W=J/s =kgm^2/s^3

eg. A 60.0 kg student runs up 23 stairs that are 36.0 cm wide and 18.0 cm high. If it takes 3.0 s,

a) what is the weight of the student?
b) what is the work done against gravity by the student?
c) What is the power of the student? convert into horsepower 1hp=746W
d) What is the work done by gravity?
e) What is the work done by the normal force?

2. What is the work done against a spring, k=2.0 N/cm pulling it from x=3.0 cm to x= 5.0cm?

Hecht p205 Problems 1, 5, 13, 27